

ABSTRACT

When seasonal pandemic occurs, hospitals will be challenged on how to place the sudden surge of patients safely. Due to the high cost, most state hospitals have minimal AIIR while some small district hospitals may not have the facilities at all. AIIR is the most effective solution for small scale airborne infection cases. However, it is highly insufficient at the peak of pandemic and is highly underused when pandemic is over. The availability of open wards makes them the next best options. The main issue when using open wards is that it may worsen infection because it is not originally designed for airborne infection isolation. The research attempts to investigate different perspectives whether open wards are feasible enough for airborne infectious isolation (AII) use in case a highly contagious seasonal pandemic crisis occur in the future. These include user's perception, spatial and ventilation perspectives. Data are collected through survey, interview, observation and measurement. Survey is conducted to investigate infection control, patient monitoring, user's comfort and safe visiting. Observation is conducted to investigate building form, orientation, vertical location, Emergency Department, core circulation, internal zoning and layout. Measurement is conducted to investigate building properties, wind speed and direction. These data are analyzed through statistical, spatial or ventilation analysis respectively. The findings of this research are correlated and thus show that open wards are not feasible in terms of safety and infection control because it is hard to achieve segregation and maximize natural ventilation to achieve air change or airflow more than 12 ACH or 160 l/s/patient. In addition, the result also shows that is also not feasible in terms of comfort and visiting but feasible for monitoring purposes only. Thus, building and ventilation retrofitting prior to the use for AII purpose is highly recommended.

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion, it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Science in Built Environment

.....

Assoc. Prof. Ar. Dr. Abdul Razak Sopian

Supervisor

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Science in Built Environment

.....

Asst. Prof. Dr. Shamzani Affendy bin Mohd Din

Internal Examiner

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Science in Built Environment

.....

Assoc. Prof. Dr Rodzi bin Ismail

External Examiner

This thesis was submitted to the Department of Architecture and is accepted as a fulfilment of the requirement for the degree of Master of Science in Built Environment

.....

Asst. Prof. Dr. Nurul Hamiruddin Salleh

Head, Department of Architecture

This thesis was submitted to the Kulliyyah of Architecture and Environmental Design and is accepted as a fulfilment of the requirement for the degree of Master of Science in Built Environment

.....

Prof. Sr. Dr. Khairuddin Abdul Rashid

Dean, Kulliyyah of Architecture and Environmental Design

DECLARATION

I hereby declare that this thesis is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

NORITA JOHAR

Signature.....

Date.....

INTERNATIONAL ISLAMIC UNIVERSITY
MALAYSIA

**DECLARATION OF COPYRIGHT AND
AFFIRMATION OF FAIR USE OF UNPUBLISHED
RESEARCH**

Copyright © 2013 by NORITA JOHAR. All rights reserved.

**“THE FEASIBILITY OF OPEN WARDS FOR AIRBORNE
INFECTIOUS ISOLATION USE DURING SEASONAL PANDEMIC
CRISIS:
A CASE STUDY OF SUNGAI BULOH HOSPITAL”**

No part of this unpublished research may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise without the prior written permission of the copyright holder except as provided below.

1. Any material contained in or derived from this unpublished research may only be used by others in their writing with due acknowledgement.
2. IIUM or its library will have the right to make and transmit copies (print or electronic) for institutional and academic purposes.
3. The IIUM library will have the right to make, store in a retrieval system and supply copies of this unpublished research if requested by other universities and research libraries.

Affirmed by NORITA JOHAR

.....

Signature

.....

Date

I would like to dedicate this thesis to my beloved parents, husband, children and all family members for their love, endless support and encouragement.

ACKNOWLEDGEMENTS

First and foremost, thank Allah for giving me the health and strength during the period of the completion of the thesis.

I offer my sincerest gratitude to my supervisor, Assoc. Prof. Ar. Dr. Abdul Razak Sopian who has supported me with his patience, careful guidance and knowledge whilst allowing me the room to work in my own way.

I am grateful to all the respondents and participants who have contributed important findings for my survey and interview.

A million thanks to all other lecturers at the Department of Architecture for the advice and knowledge shared.

I am greatly in debt to my beloved family, my spouse, children, parents and siblings for their moral support and patience.

Last but not least, I would like to thank my colleagues for the constant, careful guidance and valuable suggestions.

TABLE OF CONTENTS

Abstract.....	i
Approval Page.....	ii
Declaration Page.....	iv
Copyright Page.....	v
Dedication Page.....	vi
Acknowledgements.....	vii
Table of Contents.....	viii
List of Tables.....	xii
List of Figures.....	xv
List of Abbreviations.....	xix

CHAPTER 1 INTRODUCTION.....	1
1.1 Research Background.....	1
1.2 Problem Statements.....	4
1.3 Research Questions.. ..	5
1.4 Research Aim & Objectives	6
1.5 Research Hypothesis	6
1.6 Research Methodologies.....	7
1.7 Organization of Thesis.....	9
1.8 Scope & Limitations.....	11
1.9 Significance.....	12
1.10 Summary.....	13

CHAPTER 2 LITERATURE REVIEW.....	14
2.1 Introduction.....	14
2.2 General Information.....	14
2.2.1 Florence Nightingale & Infectious Disease.....	14
2.2.2 History of Infectious Disease.....	16
2.2.3 Infectious Disease in Malaysia.....	18
2.2.4 Transmission Mode of Infectious Disease.....	19
2.2.5 When Disease Becomes Pandemic Crisis.....	22
2.2.6 Control Measures to Prevent Spread of Pandemic.....	24
2.2.7 Types of Infection & Isolation.....	25
2.2.8 Patient Placement Procedures in Malaysian Hospitals.....	26
2.2.9 Guidelines Recommendations on Patient Placement during Crisis.....	27
2.3 Building Design.....	30

2.3.1	Planning for Isolation.....	30
2.3.2	Open Wards for Isolation.....	31
2.3.3	Infection Control through Isolation and Segregation.....	32
2.3.4	Infection Control through Cohorting in Open Wards.....	33
2.3.5	Users' Comfort, Visitor's Support & Environmental Design.....	35
2.3.6	Patient Monitoring.....	36
2.4	Ventilation Design.....	37
2.4.1	Types of Ventilation.....	37
2.4.2	Factors Affecting Natural Ventilation.....	39
2.4.2.1	Macro Climatic Factors.....	39
2.4.2.2	Building & Ventilation Design Factors	40
2.4.3	Purpose of Ventilation.....	41
2.4.3.1	Natural Ventilation and Thermal Comfort.....	42
2.4.3.2	Natural Ventilation and Air Quality.....	43
2.4.3.3	Natural Ventilation and Infection Control.....	44
2.4.4	Assessing Ventilation Design.....	45
2.5	Summary.....	47

CHAPTER 3 RESEARCH METHODOLOGIES.....51

3.1	Introduction.....	51
3.2	Pre Data Collections.....	51
3.3	Data Collections.....	53
3.4	General Data Collections: Survey.....	54
3.4.1	Target Respondents.....	55
3.4.1.1	Doctors and Nurses.....	56
3.4.1.2	Patients and Visitors.....	56
3.4.1.3	Mechanical Engineers.....	56
3.4.2	Determining Population Size.....	56
3.4.3	Determining Sampling Size.....	57
3.4.3.1	Patients and Visitors.....	57
3.4.3.2	Doctors and Nurses & Mechanical Engineers.....	58
3.4.4	Sampling Frame.....	59
3.4.5	Design of Survey Questions.....	60
3.4.6	Distribution of Survey.....	62
3.5	Specific Data Collections: Interview.....	63
3.6	Specific Data Collections: Observation.....	65
3.7	Specific Data Collections: Measurement.....	66
3.8	Data Analyses.....	72
3.8.1	Statistical Analysis.....	73
3.8.2	Spatial Analysis.....	73
3.8.3	Ventilation Analysis.....	73
3.9	Summary.....	74

CHAPTER 4 RESULTS, ANALYSES & FINDINGS.....	75
4.1 Introduction.....	75
4.2 Survey.....	76
4.2.1 Doctors & Nurses: Demographic Data.....	77
4.2.1.1 In Terms of Safety & Infection Control.....	79
4.2.1.1.1 Results.....	80
4.2.1.1.2 Analysis.....	81
4.2.1.2 In Terms of Patient Monitoring.....	81
4.2.1.2.1 Results.....	81
4.2.1.2.2 Analysis	83
4.2.1.3 In Terms of Users' Comfort.....	83
4.2.1.3.1 Results.....	84
4.2.1.3.2 Analysis	85
4.2.1.4 In Terms Safe Visiting.....	86
4.2.1.4.1 Results.....	86
4.2.1.4.2 Analysis	87
4.2.2 Patients & Visitors: Demographic Data.....	88
4.2.2.1 In Terms of Safety & Infection Control.....	91
4.2.2.1.1 Results.....	91
4.2.2.1.2 Analysis	92
4.2.2.2 In Terms of Patient Monitoring.....	93
4.2.2.2.1 Results.....	93
4.2.2.2.2 Analysis	94
4.2.2.3 In Terms of Users' Comfort.....	95
4.2.2.3.1 Results.....	95
4.2.2.3.2 Analysis	96
4.2.2.4 In Terms Safe Visiting.....	97
4.2.2.4.1 Results.....	97
4.2.2.4.2 Analysis	99
4.2.3 Mechanical Engineers: Demographic Data.....	100
4.2.3.1 In Terms of Safety & Infection Control.....	102
4.2.3.1.1 Results.....	102
4.2.3.1.2 Analysis	103
4.3 Observations.....	104
4.3.1 General Overview.....	105
4.3.2 Building Form & Orientation.....	108
4.3.2.1 Results.....	108
4.3.2.2 Analysis.....	110
4.3.3 Vertical Location.....	112
4.3.3.1 Results.....	112
4.3.3.2 Analysis.....	113
4.3.4 Emergency Department.....	113
4.3.4.1 Results.....	114
4.3.4.2 Analysis.....	115

4.3.5	Circulation at the Core.....	115
4.3.5.1	Results.....	115
4.3.5.2	Analysis.....	117
4.3.6	Internal Zoning & Layout.....	118
4.3.6.1	Results.....	118
4.3.6.2	Analysis.....	120
4.3.7	Patient Monitoring.....	121
4.3.7.1	Results.....	121
4.3.7.2	Analysis.....	122
4.3.8	Users' Comfort.....	122
4.3.8.1	Results.....	123
4.3.8.2	Analysis.....	124
4.3.9	Safe Visiting.....	125
4.3.9.1	Results.....	125
4.3.9.2	Analysis.....	125
4.4	Measurement.....	126
4.4.1	Physical Properties.....	126
4.4.1.1	Results.....	126
4.4.1.2	Analysis.....	129
4.4.2	Ventilation Properties.....	130
4.4.2.1	Results.....	130
4.4.2.2	Analysis.....	131
4.4.2.2.1	Cross Ventilation Bay.....	132
4.4.2.2.2	Mix Ventilation Bay.....	134
4.5	Discussions on Findings.....	137
4.5.1	Safety and Infection Control.....	140
4.5.2	Patient Monitoring, Users' Comfort & Safe Visiting.....	142
4.6	Summary.....	144
CHAPTER 5 CONCLUSION.....		145
5.1	Thesis Summary.....	145
5.2	Conclusions.....	149
5.3	Recommendations.....	150
5.4	Future Research.....	151
REFERENCES.....		152
LIST OF APPENDICES.....		157

LIST OF TABLES

<u>Table No</u>	<u>Page</u>
 CHAPTER 1	
1. 1 Research Questions, Objectives, Methodologies & Output	8
 CHAPTER 2	
2. 1 Chronology of infectious disease in Malaysia	18
2. 2 Influenza in Malaysia 1997-2010	19
2. 3 Transmission mode, source and example of diseases	20
2. 4 Minimum requirements of AII facilities in Malaysian hospitals	27
2. 5 Advantages & disadvantages of ventilation systems	39
2. 6 General climatic data in Malaysia	40
2. 7 Factors affecting natural ventilation	41
2. 8 ACH and time to remove nuclei	46
2. 9 Standards on recommended air changes and flow rate	46
 CHAPTER 3	
3. 1 Registration flow of Research At The CRC Sungai Buloh	53
3. 2 Statistics of H1N1 in 2009-10	57
3. 3 Criteria for choosing sampling frame	60
3. 4 Sample of survey questions	61

<u>Table No</u>		<u>Page</u>
3. 5	Observation checklist	66
3. 6	Building properties checklist	68
3. 7	Ventilation properties checklist	68
3. 8	Recommended air change & flow rate	74
 CHAPTER 4		
4. 1	Doctors & Nurses: In terms of safety & infection control	80
4. 2	Doctors & Nurses: In terms of patient monitoring	82
4. 3	Doctors & Nurses: In terms of user's comfort	84
4. 4	Doctors & Nurses: In terms of safe visiting	87
4. 5	Patients & Visitors: In terms of safety & infection control	92
4. 6	Patients & Visitors: In terms of patient monitoring	94
4. 7	Patients & Visitors: In terms of users' comfort	96
4. 8	Patients & Visitors: In terms of safe visiting	98
4. 9	Engineers: In terms of safety & infection control	103
4. 10	Ventilation data	131
4. 11	Statistical summary	141
4. 12	Spatial summary	141
4. 13	Ventilation summary	142
4. 14	Correlation summary for primary issue	142
4. 15	Correlation summary for secondary issues	147

CHAPTER 5

5. 1 Research Questions, Objectives & Methodologies

148

LIST OF FIGURES

<u>Figure No</u>	<u>Page</u>
CHAPTER 1	
1. 1 AIIR	2
1. 2 Research methodologies	7
CHAPTER 2	
2. 1 Evolution of wards diagram	16
2. 2 Global statistics for H1N1 in 2009	17
2. 3 Relationships between building and ventilation design	22
2. 4 Symptoms and complications of influenza	22
2. 5 Illustrations on pandemic crisis from phases 1-6	23
2. 6 Types of infection & isolation	25
2. 7 Recommended placement during crisis	28
2. 8 Guidelines	29
2. 9 AIIR (left) and open ward (right)	32
2. 10 Example of open wards with natural ventilation	37
2. 11 Types of ventilation system	38
2. 12 Prevailing wind in Malaysia	40
2. 13 Bioclimatic chart: comfort zone	42
2. 14 Bioclimatic chart: ventilation strategies	43

<u>Figure No</u>	<u>Page</u>
2. 15 Simplified connections between ventilation & infection	45
2. 16 Summary of building and ventilation design reviews	48
2. 17 Dependent & independent variables used in survey	49
2. 18 Variables used in observation	50
2. 19 Variables used in measurement	50
 CHAPTER 3	
3. 1 Types of data collection methods	53
3. 2 Survey respondents	55
3. 3 Sungai Buloh Hospital (left) and Sultanah Bahiyyah Hospital (right)	59
3. 4 Digital distance meter (left) & vane anemometer (right)	67
3. 5 Location for external ventilation measurement	70
3. 6 Location for internal ventilation measurement	71
3. 7 Position of anemometer	71
 CHAPTER 4	
4. 1 Survey variables	76
4. 2 Occupation	77
4. 3 Working experience	77
4. 4 Involvement with airborne disease	78
4. 5 Knowledge on airborne disease	78

<u>Figure No</u>	<u>Page</u>
4. 6 Users' experience	88
4. 7 Isolation use experience	89
4. 8 Involvement with airborne disease	89
4. 9 Knowledge on airborne disease	90
4. 10 Working experience	100
4. 11 Involvement with airborne disease	101
4. 12 Knowledge on airborne disease	101
4. 13 Entrance to AIIR at Ward 4C	106
4. 14 Hand washing facilities before entering the AIIR room	106
4. 15 Internal AIIR at Ward 4C	107
4. 16 Individual pressure controller at Ward 4C	107
4. 17 The building form	108
4. 18 The green pocket areas	109
4. 19 The low rise blocks at the perimeter	109
4. 20 The connecting bridge	110
4. 21 Juxtaposition of building form	111
4. 22 Vertical spaces at SBH	112
4. 23 The location of emergency department	114
4. 24 Circulation at the core diagram	116
4. 25 Public lift lobby	117
4. 26 Staff lift lobby	117

<u>Figure No</u>	<u>Page</u>
4. 27 Internal zoning diagram	119
4. 28 Zoning for ventilation diagram	120
4. 29 Utilities area opposite patient's bay	121
4. 30 Nurse station	122
4. 31 Internal layout use diagram	123
4. 32 Public sitting areas	123
4. 33 Patients' bay	124
4. 34 Measurement in sketches	127
4. 35 Distance, area and volume	128
4. 36 Top hung window used	128
4. 37 Diagram for actual opening	132
 CHAPTER 5	
5.1 Proposal for safe visiting	151

LIST OF ABBREVIATIONS

AII	Airborne Infectious Isolation
AIIR	Airborne Infection Isolation Room
ACH	Air Changes per Hour
API	Air Pollutant Index
CDC	Centre for Disease Control
CRC	Clinical Research Centre
DOE	Department of Environment
HEPA	High Efficiency Particulate Air
ID	Infectious Disease
JKR	Jabatan Kerja Raya
MOH	Ministry of Health
NIH	National Institute of Health
NMRR	National Medical Research Register
PPE	Personal Protective Equipments
SARS	Severe Acute Respiratory Syndrome
SBH	Sungai Buloh Hospital
SBHAS	Sultanah Bahiyah Hospital, Alor Star
SPSS	Statistical Package and Service Solutions
WHO	World Health Organization